4.1 Voortplanting van mariene dieren

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10.1 The cycle of life

All life on the planet is driven to reproduce. Evolution by natural selection favours those organisms that can reproduce the most and pass on their genes to future generations. All organisms have evolved life cycles and reproductive methods that solve particular problems associated with their ecosystem and environment.

Charles Darwin made many observations about the natural world. He made three of the most important when writing the *Origin of Species by Natural Selection*.

- Most organisms tend to 'over reproduce' during their lifetime. To replace two sexually reproducing organisms, theoretically only two offspring are needed.
- Most populations tend to remain stable. This must mean that there is a huge struggle to survive and the majority of an organism's offspring die.
- All organisms show enormous variation and only those with the best characteristics or survival strategies survive and breed, passing their characteristics on to the next generation. This is the idea of 'survival of the fittest'.

The problems that all organisms encounter are constantly changing due to numbers of predators, amount of food, climate shifts and changes to habitats. A reproductive strategy that was ideal for one generation may not be ideal for another. Some organisms provide no parental care but produce thousands of offspring (a female Atlantic herring can carry up to 50 000 eggs) in the hope that maybe one or two will survive to breed. Some organisms produce only a few offspring but nurture and guard them in an effort to improve their chances of survival to breeding age. Which reproductive strategy a particular species uses is nature's solution to a particular environmental problem. There are two reasons why studying the life cycles of marine organisms is important to us.

- It can help us create optimal conditions for farming marine creatures such as oysters and salmon.
- It can help us understand why actions such as taking small fish and altering riverbeds can have catastrophic consequences on the populations of marine species.

10.2 Life cycles of marine organisms

Organisms tend to have one of two types of life cycle:

- simple life cycles, where there are no major different stages and metamorphosis does not take place
- complex life cycles, where there are several different stages and forms of organism.

Most marine organisms (other than marine mammals, birds and reptiles) have life cycles that are complex and go through several stages. This means that the majority have larval forms of some description. There are many advantages and disadvantages to having larval forms.

KEY TERM

Larval: the immature form of animals that undergo some metamorphosis, often having different food sources and habitats to avoid competition with the adults

Larval stages

If an organism has several **larval** stages, there must be some form of benefit to the survival of the organism.

- Less competition for food. Often, larvae occupy a different niche or region of ocean compared with the adults. This means that the adults and larvae are not competing for the same food. Zooplankton is made up of many larval forms, some of which eat phytoplankton while others eat other zooplankton. Some species have several larval stages, each of which may exist in a different area and eat a different food source.
- Distribution. Where adults are sessile (fixed to a substrate), a larval stage offers the possibility of moving to another area. The adult giant clam *Tridacna gigas* is usually securely attached to the substrate, but the larvae are free to move in the ocean. When they settle to become an adult, the larvae are often situated away from the parent, which reduces competition with the parent. It also means that the species is more resistant to extinction if a disease, predator or catastrophic event (such as a volcanic eruption) affects one area. If some of the offspring live elsewhere, they may survive.

There are also disadvantages, however.

- There will almost inevitably be less parental care so there is a higher risk of mortality.

- Larval stages tend to be small and free floating, and as a result may be more susceptible to predation and environmental stresses such as pollution and temperature change.
- Lack of substrate. Distribution across different areas does not necessarily mean that there will be a suitable substrate or food source in each area. Many larvae will be lost and simply die because they end up in an inhospitable area.

Salmon life cycle

There are many different species of wild salmon, broadly divided into Atlantic salmon (genus *Salmo*) and Pacific salmon (genus *Oncorhynchus*). There is one species of Atlantic salmon (*Salmo salar*) but several species of Pacific salmon, including chinook, chum, sockeye and pink.

Most salmon species have a very similar life cycle, which involves spending a significant part of their lives in both fresh water and seawater (Figure 10.1). There are a few species, such as the Danube salmon, that live their lives exclusively in fresh water.

Salmon both begin and end their lives in fresh-water rivers. There are distinct male and female sexes and they do not change sex within their lifetime. In the autumn, sexually mature salmon swim far upstream in the rivers where they were spawned. The females seek out deep, free-flowing water with gravel beds. They dig out a scrape of gravel called a redd and lay their eggs in it. The male then deposits sperm over the eggs. Depending on the species of salmon, the female may lay between 2500 and 7000 eggs. When finished, the female buries the eggs in the gravel using her fins, in order to protect them through the winter. It is essential that the river flow is neither too fast nor too

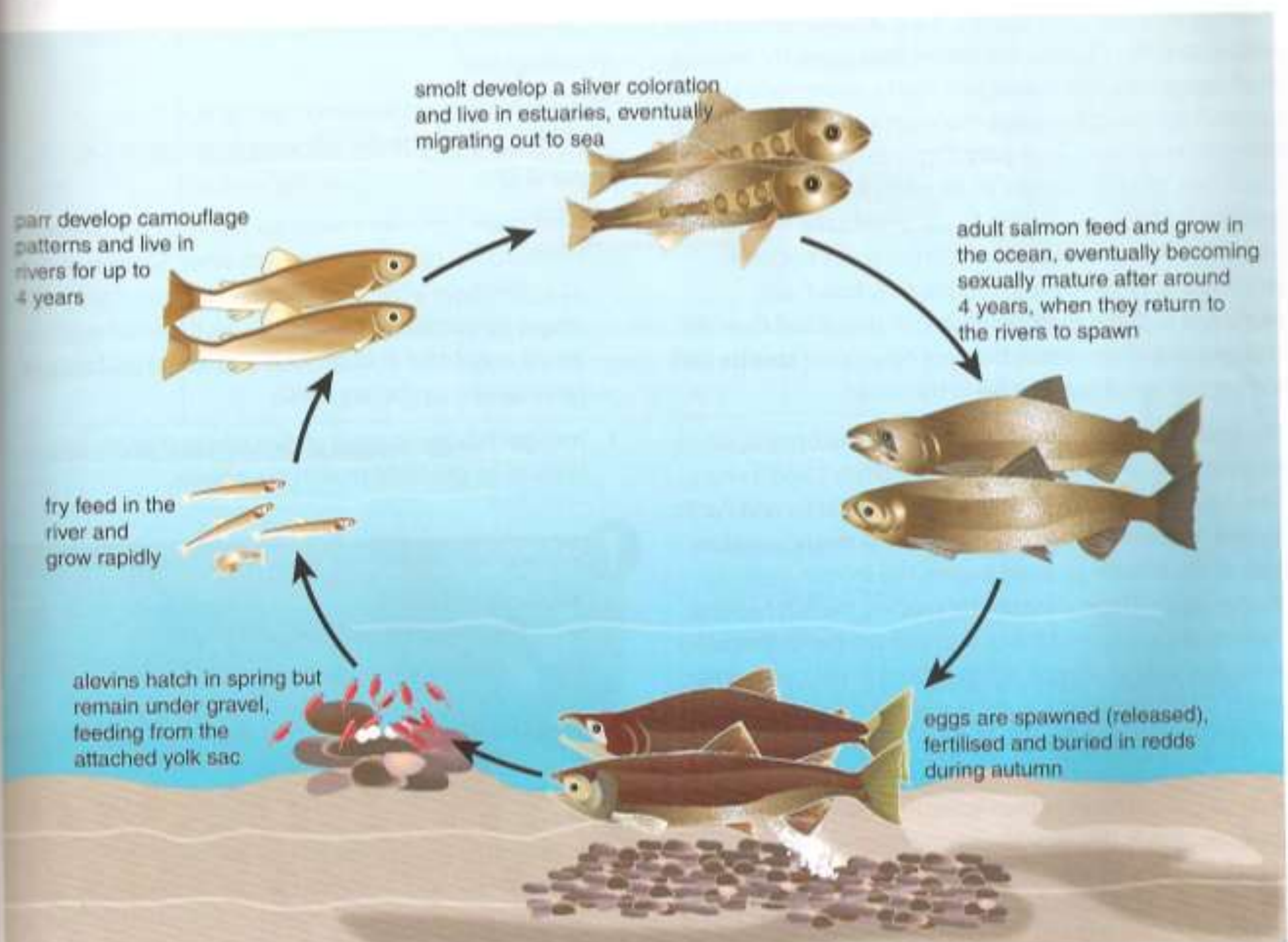

Figure 10.1. The life cycle of salmon.

slow. Too fast, and the gravel and eggs will be washed away; too slow, and the developing embryos have too little oxygen. The temperature of the water is also critical. Too warm, and the embryos will develop too quickly and hatch at the wrong time of year; too cold, and their development will be delayed.

The eggs develop over winter and hatch into **alevins**. These tiny fish still have an attached yolk sac filled with nutrients and stay hidden within the gravel nest out of reach of most predators. As the alevins grow, the yolk sac decreases in size and the fish have to start finding their own food supply. After the yolk has been completely used up, the salmon are called **fry** and leave the redd. They swim to the surface to fill their swim bladders with air so that they can swim freely throughout the whole depth of the river in an effort to avoid predators. Fry are too weak to swim upstream so tend to be washed downstream, actively seeking out calmer areas of water, which they will defend against other fry. They feed voraciously on invertebrates and grow rapidly. It is a very vulnerable stage and up to 90% of the fry can die. As they grow, fry develop markings on the side called parr marks, which help to camouflage them. Once the markings are complete, the salmon are referred to as **parr**. Depending on the species of salmon, the parr remain in the rivers feeding and growing for between 1 and 4 years. Eventually, the parr move to the river estuaries, where the water becomes more saline. While in the estuaries, they lose their markings, become more elongated in shape and their skin changes to a silver colour; they are now called **smolts** and are becoming adapted for life in the ocean.

The smolts move in shoals into the seas and oceans, where they will remain for between approximately 1 and 5 years. They feed in the rich waters of the north Atlantic and Pacific oceans. While in the sea, the fish become sexually mature and, as the breeding period begins, the salmon begin to change again. Depending on the species, the fish become more brightly coloured (often red) and the jaw of the males elongates to form a kype, which is used to fight with other males. The proportions of red and white muscle in the fish changes so that there is a higher proportion of white muscle. Red muscle contains high levels of myoglobin and more mitochondria than white muscle. Myoglobin stores oxygen in the muscle and, together with the mitochondria, helps aerobic respiration for long-distance swimming in the oceans. White muscle has less myoglobin and fewer mitochondria and is adapted for sudden bursts of energy, which are necessary for jumping over obstacles in rivers.

The adult fish undertake an extraordinary migration up to the riverbeds where they were hatched. The salmon seem to be able to detect specific chemicals from their 'own' river and move towards it. These mass salmon migrations, called runs, are extremely important in the ecology of many parts of the Northern Hemisphere and salmon are considered a keystone species. As the salmon swim upstream in huge shoals, predators such as bear, otters and osprey lie in wait to eat them during the annual migration. The loss of salmon would be a huge ecological catastrophe because so many food chains depend on them. Eventually, the salmon reach the gravel beds of their river and spawn, continuing the life cycle. All species of Pacific salmon die after spawning. The majority of Atlantic salmon also die after spawning but between 5 and 10% of the females return to the ocean to enter another breeding cycle.

The advantages of the salmon life cycle, with so many stages, include the following (summarised in Table 10.1).

- Each stage occupies a separate niche, so the different forms do not compete with each other. Salmon of all stages have a high food requirement, so if several stages co-occupied the same niche, the smaller fish would not obtain enough food and would probably be cannibalised by the larger fish.
- Younger fish live in areas of river where they are less likely to be predated than in the oceans.

KEY TERMS

Alevin: the first larval form of salmon, they possess a yolk sac and remain within the gravel nests or redds

Fry: the early, small larval stage of many fish, including salmon

Parr: salmon stage between fry and smolt; lives in rivers and has markings along sides of body that act as camouflage

Smolt: form of salmon that occurs when parr lose their markings while in estuaries; they are adapted for marine life by being silver in colour and elongated in shape

stage	habitat	advantages	time duration	other features
fertilisation and embryonic development	gravel beds of rivers	hidden from predators, in running water with plenty of oxygen	c. 4–5 months	must be in deep, flowing water that is cool in temperature
alevin	gravel beds of rivers	hidden from predators, running water with plenty of oxygen	c. 4–6 weeks	nourished by yolk sac so can remain inside gravel nests
fry	flowing water, sheltering behind rocks and other obstacles	food and oxygen is carried in the water, less likely to be swept away by currents because of the shelter	c. 3 months	a phase of rapid growth, fry will defend territories aggressively
parr	deeper pools in river areas	abundant food present in the deeper pools as growth requires more nutrients	c. 1–4 years	the development of camouflaged coloration reduces risk of predation in rivers
smolt	estuaries of rivers	high food abundance and preparation for change in salinity in the oceans, different food sources so not in competition with parr	variable depending on conditions	smolt develop silver colour and streamlined shape for life in the ocean, they also begin to osmoregulate in saline water
adult	oceans and seas	different and rich food source that is not in competition with younger stages	c. 2–4 years	adults feed on rich food such as crustaceans and are voracious predators
sexually mature adult	oceans and seas, and rivers	rich food source in the ocean and appropriate spawning areas in rivers	c. 1 year	males and females change colour and become clearly distinguishable

Table 10.1. A summary of the salmon life cycle.

SELF-ASSESSMENT QUESTIONS

1 List two advantages and two disadvantages of having a larval stage in a life cycle.

2 State why it is important that salmon fry live in moving river water.

Tuna life cycle

There are several different species of true tuna fish, all belonging to the genus *Thunnus*. The main species are:

- Albacore tuna
- southern bluefin tuna
- bigeye tuna
- Pacific bluefin tuna
- Atlantic bluefin tuna.

All these tuna species have a similar life cycle, although some differences occur with spawning grounds and ages at which sexual maturity develops. Sexes appear to be fixed and there are no records of tuna changing sex during their lives.

Male and female tuna migrate to spawning grounds in the Atlantic and Pacific oceans and Mediterranean Sea at certain times of year. The breeding seasons vary for each species and may also depend on the water temperature of the spawning grounds. There are two separate populations

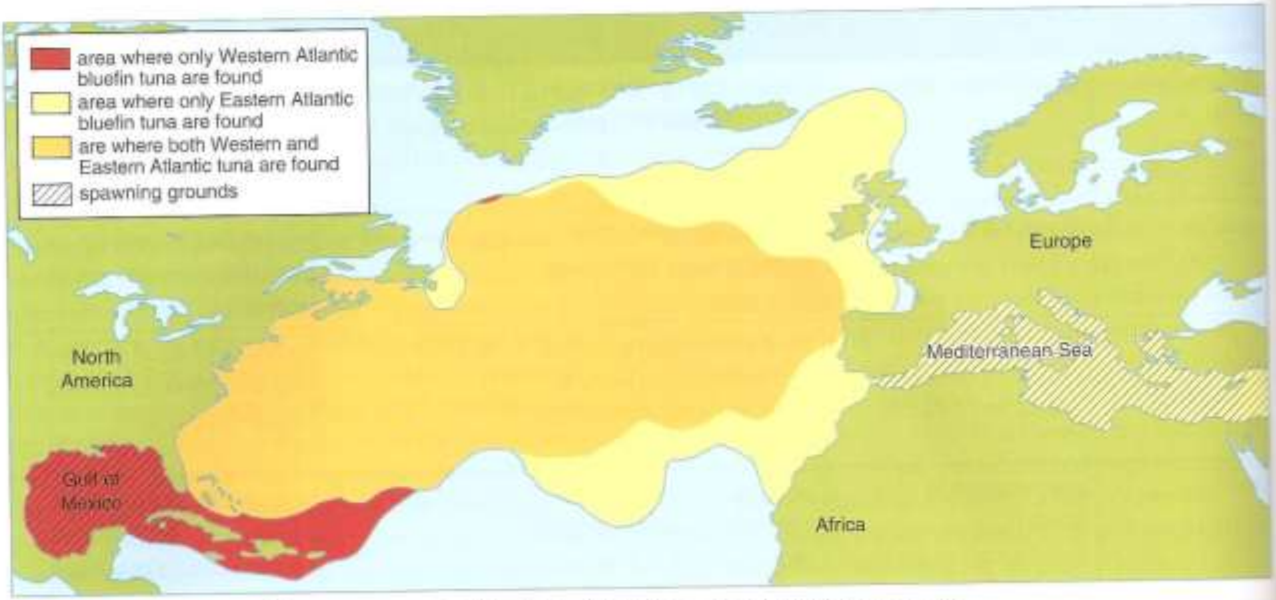

Figure 10.2. The ranges of the two groups of Atlantic bluefin tuna and their spawning grounds.

of Atlantic bluefin tuna that either gather in a region of the Mediterranean near the Balearic Islands between May and July, or in the Gulf of Mexico between April and June. Pacific bluefin congregate in distinct spawning grounds in the north-west Philippine Sea and the Sea of Japan between April and August (Figure 10.2). By congregating in the same areas, it increases the likelihood of successful mating and means that genetically different tuna breed together, increasing genetic diversity.

Recent research using tagging has shown that tuna, like salmon, return to the spawning ground in which they themselves were spawned. Males and females swim together during spawning, which generally occurs at night. During spawning, many females release eggs into the water while males release sperm. This is called broadcast spawning because eggs and sperm from many individuals are in the water together. The random, external fertilisation results in increased genetic diversity, although many eggs are lost. The fertilised eggs, which are buoyant because of the presence of oils, float just beneath the surface of the water, where many are eaten by predators.

Each female can produce vast numbers of eggs, depending on their size; a 5-year-old female bluefin tuna releases about 5 million eggs in a year whereas a 20-year-old female can release up to 45 million. Such huge numbers are produced because the majority will fail to fertilise or be eaten as eggs or larvae.

Larvae hatch after about 2 days and live in the planktonic surface waters, where they feed on the larvae of all species. They have disproportionally large heads and jaws to enable easy feeding (Figure 10.3). The larvae remain in the spawning grounds, growing rapidly, until they reach a certain size, when they move out into the open ocean feeding grounds. These **juvenile** fish tend to school together to avoid predators. Different species reach sexual maturity at different ages, typically between 4 and 8 years of age, at which point they will migrate to the spawning grounds to mate.

KEY TERM

Juvenile: the stage of life cycle that is not sexually mature

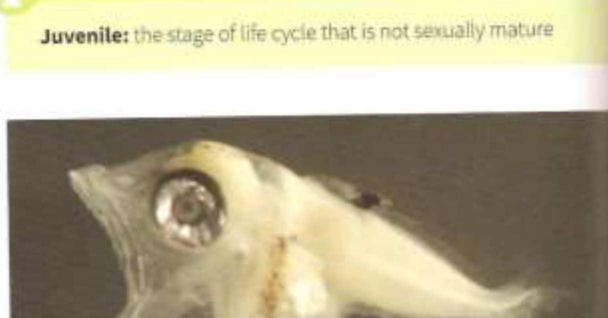

Figure 10.3. Tuna larva, showing its large mouth and head region.

The advantages of the tuna life cycle are as follows.

- It allows synchronisation of male and female tuna in a few areas at one particular time rather than navigation of vast areas of ocean in the hope of finding mates. This means that many males and females are present, increasing the genetic diversity of the population.
- The separate larval stage means that tuna of different ages are not competing for the same food stock.
- The spawning grounds have abundant food for the larvae, which is less available in the adult feeding grounds.

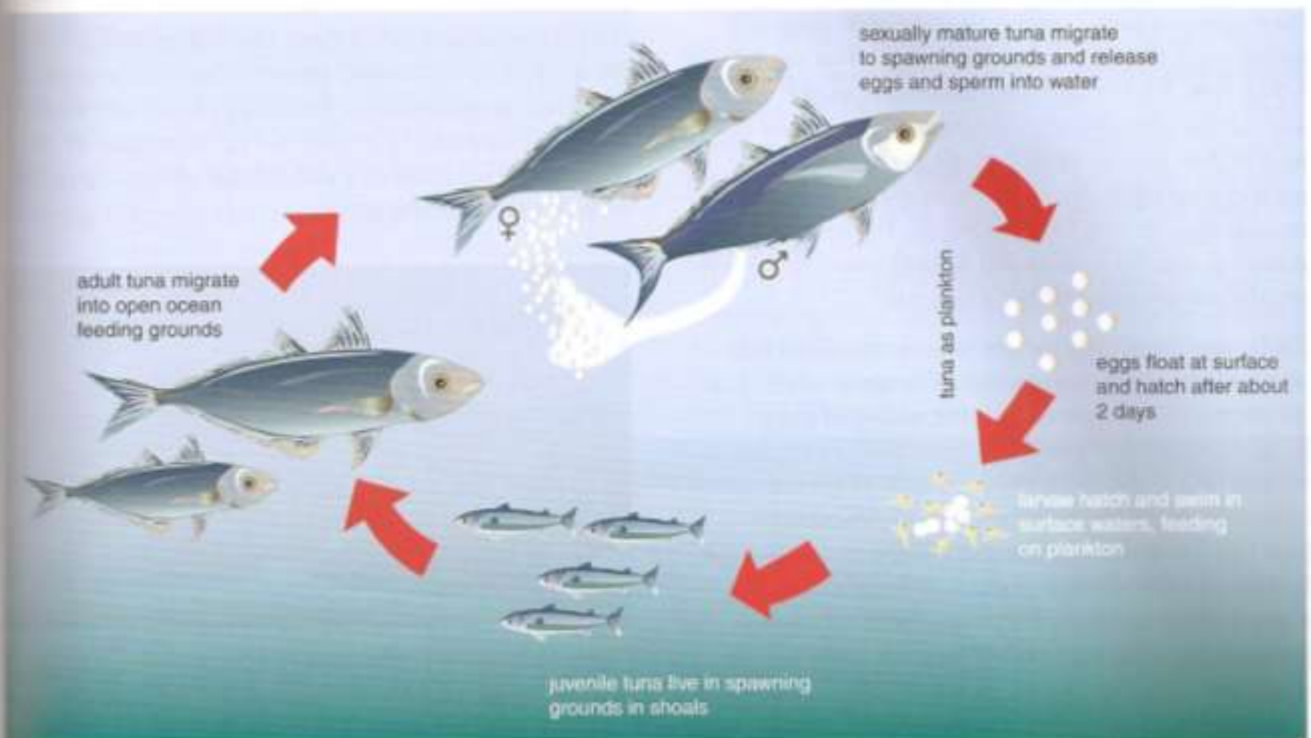

Figure 10.4. The life cycle of tuna.

stage	habitat	advantages	time duration	other features
fertilisation and embryogenesis	spawning ground area of ocean water	allows many males and females to be in close proximity	c. 2–4 days	many unfertilised and fertilised eggs are lost so females lay millions each year
larval stage	planktonic zone of spawning ground	rich feeding area, not in competition with adults	c. 6 months	larvae have large heads and mouthparts to obtain food
juvenile	spawning grounds and open ocean feeding grounds	move in shoals of similar size to evade predators, have different and larger food than larvae	c. 5 years, depending on species	juveniles leave the spawning grounds in shoals and roam the oceans feeding, they have a high growth rate
adult	open ocean feeding grounds	rich diversity of food, not in competition with larvae	5–25 years, depending on species	adults migrate to the spawning grounds where they themselves were spawned during breeding season

Table 10.2. A summary of the tuna life cycle.

Oyster life cycle

Oysters are bivalve molluscs that as adults are sessile (attached to a substrate and unable to move to another region). They have a complex life cycle that has several stages (Figures 10.5 and 10.6). The larval stages allow the oysters to disperse their offspring to different areas, although they tend to settle in beds where there are other oysters already growing.

The majority of oyster species have separate male and female sexes, although most will change sex at some point in their lives. It is thought that individuals can change sex multiple times. Most species live for the first few years of their lives as males and release sperm. As they age and grow bigger they have more energy available to develop eggs, so they become female. They use broadcast spawning, with both males and females releasing gametes into the water, so fertilisation is external.

The factors controlling gamete release are still not fully understood but it is thought that a change in water temperature is a trigger causing the release of sperm from a few males. A synchronising pheromone is probably released into the water at the same time. When one oyster releases its gametes, the others, of both sexes in the local bed, are stimulated to do so in order to synchronise fertilisation. It is common practice to throw a male that is about to spawn into farmed oyster beds in order to stimulate breeding by the whole bed. For many species, a temperature of 16 °C seems to be critical for breeding, and as soon as the temperature rises above this in spring breeding starts; and conversely breeding stops when the temperature drops below 16 °C in autumn. Many species tend to breed between May and August, hence the old saying that you should only eat oysters when there is an 'r' in the month. This is because, during the breeding season, oysters put most of their energy into their gametes so tend to have less 'meat' in them. External fertilisation in the water, despite the synchronised release of gametes, is very much down to chance; many eggs do not get fertilised and many are eaten by predators. To compensate for this, each female will produce a vast number of eggs, up to 100 million year^{-1} for some species.

Figure 10.5. Oysters releasing gametes.

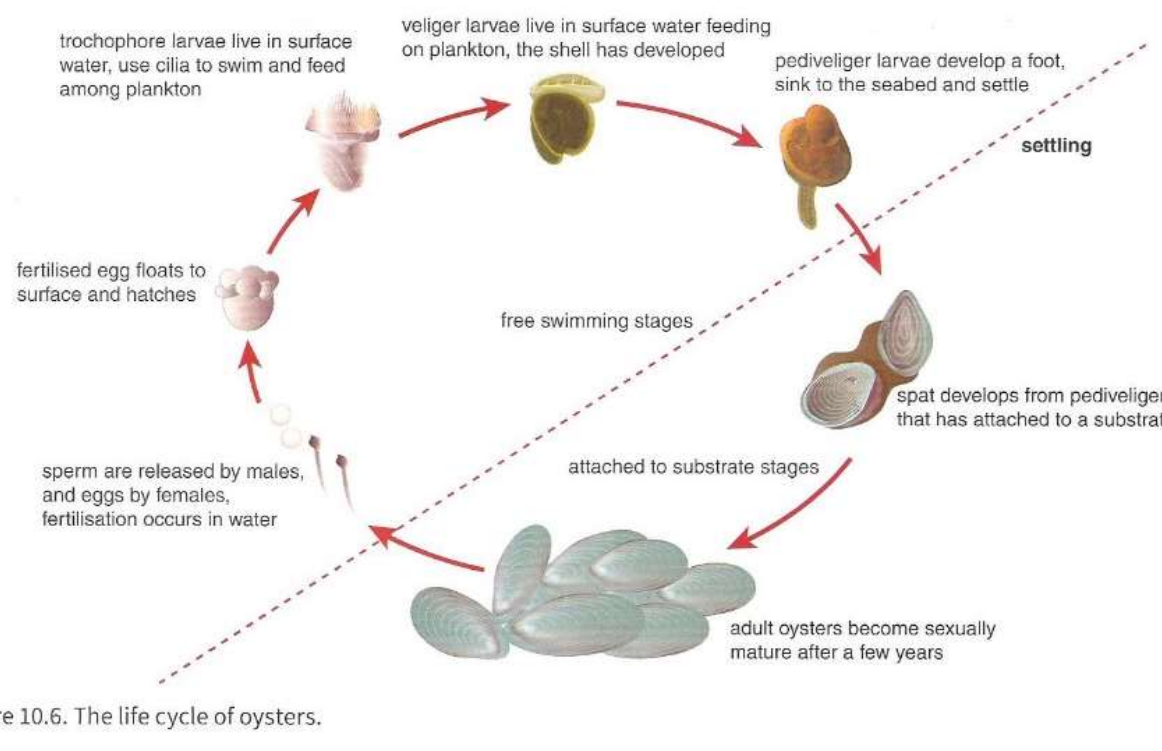

Figure 10.6. The life cycle of oysters.

KEY TERMS

Trochophore: the first larval stage of molluscs such as giant clams and oysters, they move using cilia and are planktonic

Veliger: the second-stage larva of molluscs, characterised by the presence of a vellum organ used for feeding and movement, and a shell

Pediveliger: the third-stage larva of molluscs, characterised by the development of a foot

Spat: larval form of oyster, giant clam and other bivalve molluscs that settles and attaches to substrate

The eggs hatch between 6 and 12 h after fertilisation and develop into the first free-swimming larval stage, called a **trochophore**. These larvae have cilia on their surface in order to move through the water while feeding on phytoplankton. After a short time, the trochophore larvae begin to develop a shell and an organ called a vellum, which is coated with cilia and used for movement and feeding. The larva is now called a **veliger** larva. Eventually, the veliger larva begins to grow a foot with which it can attach to a substrate, and is now called a **pediveliger** larva. Pediveligers sink to the seabed and swim over it, dragging their foot on the substratum. The foot is highly sensitive and can detect a suitable site for settling and also seems to be attracted to chemicals from other oysters. When an ideal location is found, glands in the foot release various secretions that stick the pediveliger to the substrate. The byssus thread, a tough material that is produced by many molluscs for attachment, is one such secretion. The larvae then undergo metamorphosis into adults, becoming small oysters or **spats**. Spats spend up to 3 years feeding and growing before reaching sexual maturity. The length of time between fertilisation and settling varies from species to species and is dependent on the conditions of the water, but is typically between 2 and 3 weeks. The whole life cycle is summarised in Table 10.3.

stage	habitat	advantages	time duration	other notes
fertilisation and embryogenesis	water around seabed	oysters grow together so the chance of fertilisation is high	c. 6–12 h	there are separate male and female oysters but oysters change sex during their lives, females release up to 10 million eggs $year^{-1}$
trochophore	planktonic surface waters	free swimming for dispersal, not competing with adults for food	c. 5–10 h	trochophore are minute, free-swimming larvae that use cilia to move and feed
veliger	planktonic surface waters	free swimming for dispersal, not competing with adults for food	c. 1 week	veliger larvae have a velum that possesses cilia for movement and feeding, and also a shell
pediveliger	planktonic surface waters	free swimming for dispersal, not competing with adults for food, sink to find suitable substrate, attracted to other adult oysters, good food source and mates available	c. 1–2 weeks	the pediveliger is characterised by the development of the foot, which it uses to sense and attach to the substrate
spat	attached to substrate	situated around other oysters that are growing in an area rich in food	2–3 years	the spat is a small version of the adult that grows for several years before becoming sexually mature
adult	attached to substrate	situated with other oysters in an area rich with food and near other individuals for breeding	c. 3+ years	most oyster species begin as males and later become female

Table 10.3. A summary of the oyster life cycle.

SELF-ASSESSMENT QUESTIONS

3 State one advantage and one disadvantage of broadcast spawning.

4 State one difference and three similarities between the life cycles of giant clams and oysters.

Shrimp life cycle

There are hundreds, possibly thousands, of different species of shrimp, many of which have different life cycles. There are certain common themes, however, that occur in the life cycles of all shrimps, so the general principles are given here. Shrimps are decapod crustaceans and are closely related to lobsters and crabs. They are of significant commercial interest, both when fished and farmed, and shrimp farming has led to renewed interest in their reproductive behaviour.

Adult, sexually mature shrimp live in deeper ocean waters (Figure 10.9). Breeding seasons vary from species to species, and breeding may be triggered by a mixture of water temperature and lunar phases. Sex determination is not fully understood in most crustaceans. Some species initially develop as males for 2 or 3 years and then become females; in other species the sexes are fixed for their entire lives.

Figure 10.9. Adult shrimp; the lower shrimp has eggs attached.

Shrimp are not broadcast spawners, and individual males and females mates with each other in deep ocean water (Figure 10.10). During mating, the male attaches a pouch of sperm called a spermatocyst to the underside of the female. As eggs are released by the female, sperm is released onto them from the spermatocyst so that they are fertilised externally. This is a far less wasteful process than broadcast spawning so fewer eggs need to be produced by a female, typically between 900 and 3000. In some species, such as the pink shrimp *Pandalus borealis*, the fertilised eggs remain attached to the female until they hatch 5 or 6 months later. Other species, such as the tiger prawn *Penaeus monodon*, release the fertilised eggs into the water.

KEY TERMS

Protozoea: the second-stage larva of crustaceans such as shrimp; typically planktonic, these larvae pass through several forms as they grow

Mysis: the later larval form of crustaceans; shrimp mysis larvae drift to coastal areas

A nauplius larva hatches from the egg and moves to the surface waters, where it feeds on plankton. The nauplius larvae are characterised by appendages on their heads that are used for swimming, and the presence of a simple eye. After some time feeding in the plankton, they metamorphose into a different larval stage called a **protozoea**. The protozoea larva continues to feed on plankton and passes through several moults of its exoskeleton as it grows to eventually produce a larger, more typically shrimp-like, larva called a **mysis**. The mysis larvae are carried on ocean currents towards the coast and settle in nutrient-rich areas such as mangrove swamps, estuaries and bays. They move to the estuary floor and feed on detritus and small organisms, and metamorphose into a postlarva, which resembles a small adult shrimp. These postlarvae tend to move to the shallow estuarine waters, where they become increasingly predaceous before growing into juvenile shrimps. The juvenile shrimps move into the deeper estuarine waters in search of larger prey (often being cannibalistic) and more detritus. When the juveniles approach adult size, they begin to migrate back out to the deep sea, where they become sexually mature adults and begin to breed. The life cycle is summarised in Table 10.5.

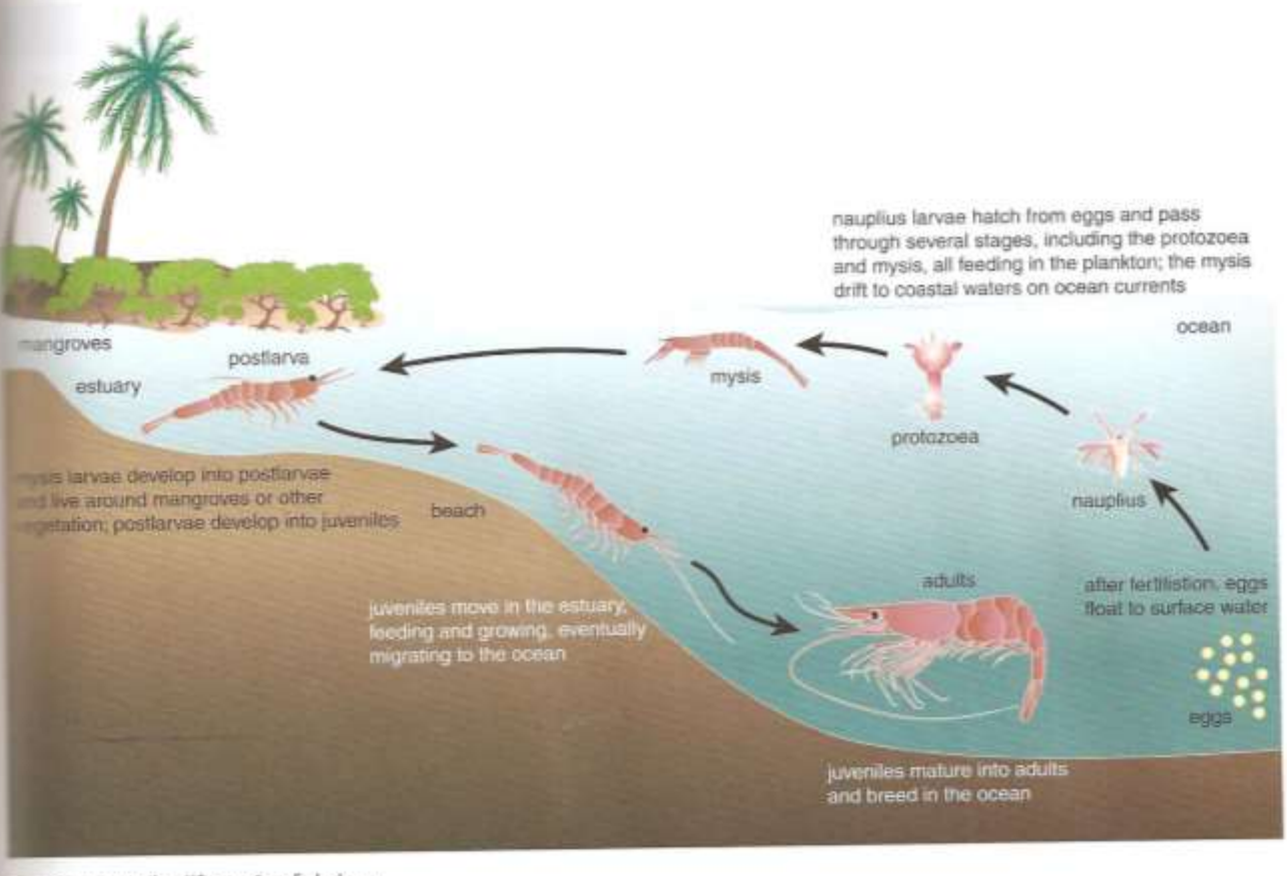

Figure 10.10. The life cycle of shrimp.

stage	habitat	advantages	time duration	other notes
fertilisation	deep sea	abundant food for adults and plenty of potential mates	c. 6 months	most shrimp begin life as males and become females after about 3 years, fertilisation is external but males and females pair up
nauplius	planktonic in surface waters	abundant food in plankton and not in competition with later stages, distributed by ocean currents	variable (a few days)	small larva with appendages on head, feeds on phytoplankton
protozoea	planktonic in surface waters	abundant food in plankton and not in competition with later stages, distributed by ocean currents	variable (a few days to weeks)	passes through several stages as it grows and sheds exoskeleton at each stage
mysis	planktonic in surface waters, swept to coastal waters by ocean currents	abundant food in plankton and not in competition with later stages, distributed by ocean currents	variable (a few days to weeks)	begins to resemble the adult shrimp, locates mangrove and seagrass areas, which act as nursery grounds

10.3 Fertilisation methods and parental care

If the cycle of life is to continue, it is essential to ensure that gametes (sperm and eggs) meet. The fusion of sperm and eggs is called fertilisation. There are essentially two options for fertilisation:

- **external fertilisation**, which occurs outside the body
- **internal fertilisation**, which occurs inside the body.

KEY TERMS

External fertilisation: when gametes such as sperm and eggs are released and fuse outside the body

Internal fertilisation: when gametes such as sperm and eggs fuse inside the body of a parent

External fertilisation

When gametes are released outside the body for fertilisation, there is some degree of uncertainty about them meeting. In order to try and improve the odds of successful fertilisation, most species have adapted their physiology or behaviour in a specific way.

Most marine organisms use external fertilisation. Organisms such as giant clams and oysters use broadcast spawning, where gametes are released into the water. It is pure chance whether one gamete meets another, and there is little, if any, choice of mate. Broadcast spawning can be a highly wasteful process because there may be no suitable mates nearby. This means that the majority of eggs and sperm simply drift away in the water currents or are eaten by predators. To compensate for the inefficiency of broadcast spawning, many species release massive numbers of eggs and sperm (up to half a billion eggs from one giant clam, for example). Gamete release is synchronised with other individuals by using chemical signals in the water to help ensure that fertilisation occurs. They maximise the chances of fertilisation by aggregating in the same area to simultaneously release gametes. So why does such an inefficient and seemingly random process exist? The answer is that the potential for so many fertilisations between so many different individuals can generate great genetic diversity, which is important for evolution.

Shrimp and salmon also use external fertilisation but produce far fewer eggs. In both cases, efforts are made to reduce the loss of gametes. Salmon pair up and make redds or nests in gravel, where they deposit the eggs. The sperm are released directly onto them. Male shrimp stick packages that contain sperm onto hairs on the females' bodies. This means that as eggs are released, sperm are already present. The methods used by salmon and shrimp help to make fertilisation far more likely, but there are costs to these adaptations. Individuals need to physically find each other and pair up. Unlike broadcast spawning, each individual has fewer partners so less genetic diversity is the result. This means that species with fewer partners tend to have complex methods of mate choice to make sure individuals choose the 'correct' partner with which to mix their genes.

Internal fertilisation

Internal fertilisation requires one organism to introduce its gametes inside another so that fertilisation can take place inside the body. This means that there is a far higher probability that fertilisation will occur. As animals evolved on land and became less dependent on water, internal fertilisation became more important because externally released gametes would dry up and be lost. Gametes can drift and swim in water, so external fertilisation is more likely to be successful if they are released in aquatic environments than into air or onto land. Marine mammals such as whales and dolphins are ancestors of terrestrial mammals (they are thought to be related to the group of animals that gave rise to hippos) and use internal fertilisation. Male whales, like all mammals, have a penis for introducing sperm into the female vagina. Once deposited in the vagina, the sperm swim up to the fallopian tubes and, if an egg has ovulated, they may fertilise it. During the breeding season, female whales become fertile and, along with the males, migrate to breeding grounds. Complex courtship routines occur between the sexes and the females choose males to mate with. Most whale species are not monogamous, and both sexes will mate with several different partners during one breeding season. In an effort to gain a competitive advantage, male whales make large quantities of sperm to try and displace a previous male's sperm. If successful fertilisation occurs, a female whale will become pregnant with one calf fathered by one of the males in the breeding group.

Sharks are unusual among fish in having internal fertilisation. The male shark has special adaptations called claspers, which are modified pelvic fins. A tube runs through the claspers through which sperm are ejected. During mating, the male inserts one of the claspers into the female shark's reproductive cavity, called a cloaca, and ejects sperm through the clasper. Internal fertilisation is beneficial for sharks for two main reasons. Some sharks live solitary lives, or live in single-sex groups until the breeding season, and do not often come across a potential mate. It is therefore essential that sharks try to ensure reproductive success by actively transferring the gametes from the male to female. Most species of shark invest a large amount of parental care in their offspring to help ensure their survival.

Parental care

Evolution by natural selection has created two opposing reproductive strategies for passing on genes to the next generation: the ***r*-strategy** and the ***K*-strategy**.

KEY TERMS

***r*-strategist:** an organism that produces large numbers of offspring while providing little parental investment

***K*-strategist:** an organism that produces few offspring but provides a large amount of parental investment

r-strategy

Many marine organisms produce millions of offspring and simply release them without any care or additional nourishment other than a yolk sac or nutrients in the egg. The survival of these offspring relies on chance; mortality rates are high and possibly less than 1% of them will survive. A giant clam may produce half a billion eggs in a breeding season but only one or two may actually survive. There is even the risk that none will survive.

K-strategy

The alternative approach is to produce fewer offspring and invest more energy in nurturing them. It would be impossible to guard and nurture half a billion offspring, but if there are far fewer offspring, it is feasible to make the effort to feed and defend them. However, there is still the risk that with only one or two offspring none will survive.

Tuna

Tuna are *r*-strategists. A female bluefin tuna can produce up to 25 million eggs every year, of which only a fraction will ever survive to become an adult tuna. No care is given to the larval stages, which have to take their chance within the plankton of the oceans.

Whales

Whales are *K*-strategists. As mammals, they are viviparous animals, meaning that the offspring develop inside the mother. The developing calf is located in the mother's uterus and obtains its nutrients from her blood via the placenta and umbilical cord. Different whale species have different gestation periods, ranging from 10 months for the humpback whale to 16 months for the sperm whale. Only one calf is born at a time and it is protected and nurtured by its mother, taking from milk from her mammary glands for between 4 and 11 months. The calves often remain with their mother or in family groups until they become sexually mature, which can be anything from 2 to 5 years, depending on the species. Some species, such as the sperm whale, are known to share 'babysitting' duties within their family groups and older calves will sometimes help raise the younger ones.

Sharks

Shark species use a range of reproductive strategies, but most are considered to be *K*-strategists because a lot of parental care is invested in a few offspring. Three main methods are used by different shark species.

Oviparity

After fertilisation, the females of some shark species lay characteristic eggs often called mermaid's purses. These are attached to rocks or seaweeds and are often guarded by the female. The egg cases contain the developing embryo, which is attached to a yolk sac that contains a high concentration of nutrients. When the yolk sac is depleted of nutrients, the young shark hatches from the egg case as a fully formed, small version of the adult shark.

Ovoviviparity

Some sharks produce live young. In many cases, the eggs are fertilised internally in the female's body and then carried inside her until they hatch, eventually passing out as live young. There is a good supply of oxygen inside the mother and, by being inside her body, there is little chance of the young being eaten by predators. While inside the body of the female, they develop inside their egg cases using a yolk sac for nutrition. Some juvenile sharks are brooded inside the mother's body for longer in order to be protected for longer. This means the young need a further food supply. Thresher and porbeagle shark juveniles eat unfertilised eggs (oophagy) that are continuously ovulated by the mother so that they are born at a larger size. The sandtiger shark and grey nurse shark take this a stage further, with embryophagy or intrauterine cannibalism. Prior to birth, the developing sharks swim around the mother's uterus killing and cannibalising their siblings so that eventually only one or two larger sharks are born. A fully grown sandtiger shark is about 2.5 m long; the juvenile is almost 1 m long when born so is large and strong enough to avoid most predators immediately after birth.

Viviparity

Some shark species, such as hammerheads and bull sharks, are classed as viviparous. They give birth to fully formed live offspring that have been nourished from the mother via a placenta. During their development, these embryos use up the yolk and then parts of the egg covering, and the yolk placenta attaches to the uterine wall in a similar way to the placenta of mammals. A cord containing blood vessels, similar to an umbilical cord, enables blood transport to and from the placenta. The developing shark is able to pass waste products into the mother's blood and gain nutrients such as glucose and amino acids for growth from the mother. When born, these sharks are fully developed and can swim away from their mother to live independently straight away.

SELF-ASSESSMENT QUESTION

7 Summarise the differences between *r*- and *K*-strategies, giving named examples of marine organisms for each.

Opdracht bij les 4.2

- Haai ontleden
- Werken aan PO